

ESS PROGRAM REVIEW

Extending DER Transient Loadability Using Electrochemical Capacitors

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Project Summary

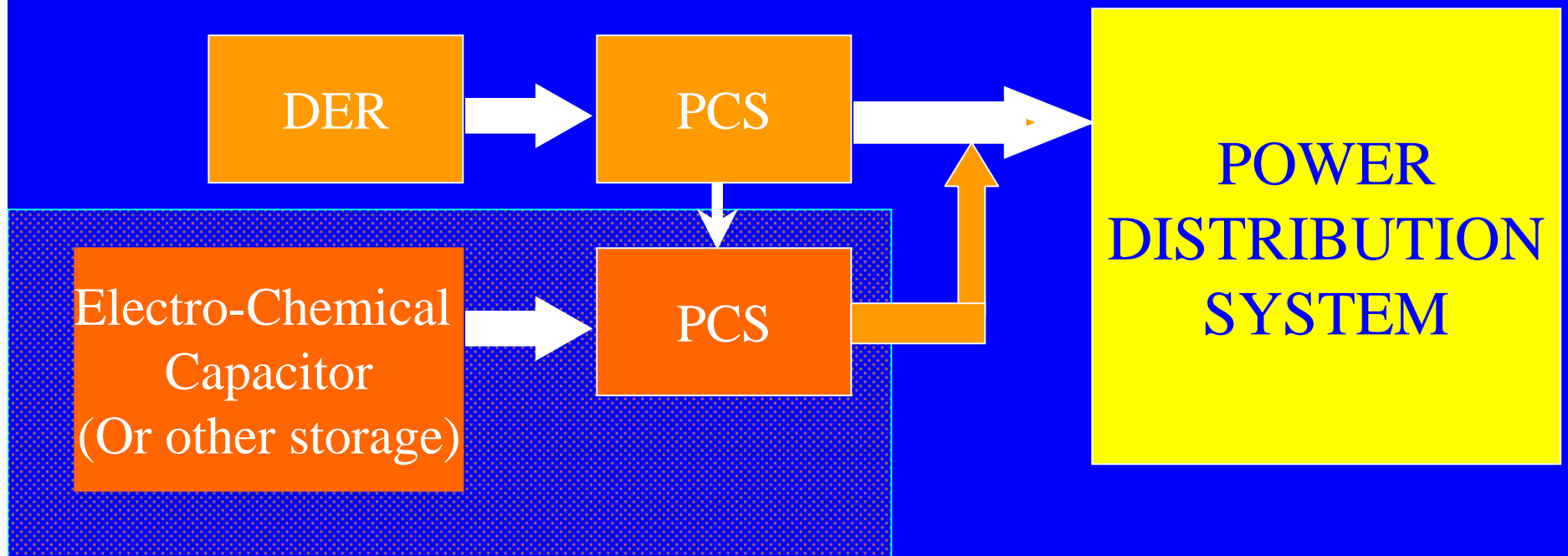
Objective

Distributed Energy Resources (DER) have problems responding to transient load such as motor start

Investigated the use of energy storage to assist DER and improve transient loadability

SUMMARY

Proposed Device



PCS – Power Conditioning System an electronic dc-ac or similar converter

Project Summary

- Developed simulation model using data for commercial capacitors
- Performed design studies to size capacitor and power conversion system
- Initiated hardware design for cost evaluation and concept testing
- Anticipate testing in FY02

Presentation Outline

- Motivation
- Overview of Conceptual/Design Study
- Future Plans (Implementation/Testing)

DER AS A TRUE RESOURCE

- Distributed Generation Resources are becoming important components of electric energy supply picture
- Generally designed for grid-connected application--islanded operation still a matter of debate
- Would be a true 'resource' if islanded 'micro-grids' were permitted/viable
- One limitation to viable islands is the need to handle transient loads – starting of a medium or large motor

MOTIVATION

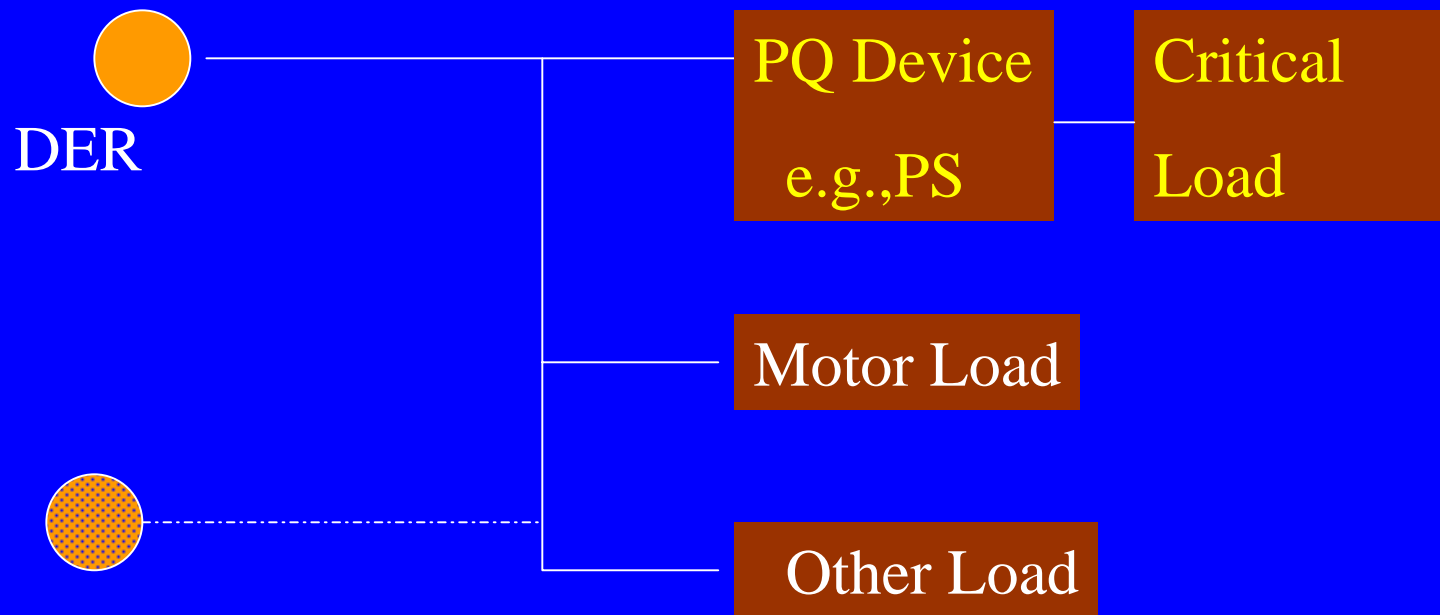
- DER-Load-Utility Interconnection is through an inverter (dc-ac power conditioning system PCS)
- Inverter Semiconductors are sized to generation capacity plus 25% safety margin(not overload capability)
- ac induction motors require six times the normal current when starting--can exceed PCS capability
- PCS can be designed for some surge capability
- Typical PCS will either reduce voltage or trip

MOTIVATION

- Assume Islanded operation is desirable
- With a single DER the voltage quality/availability is compromised
- With an islanded DER cluster the viability of the entire island is compromised

Possible Solutions to Motor Start Problem

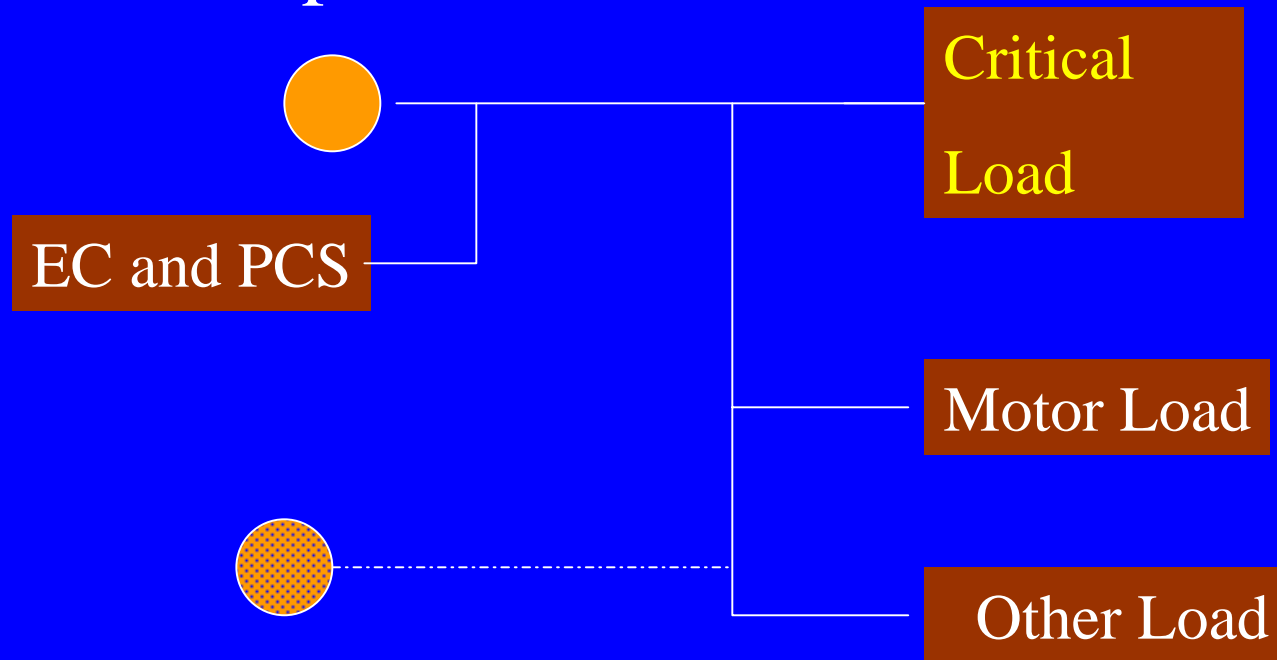
- Conventional-- Load Side



Other load, and other DERS may be compromised

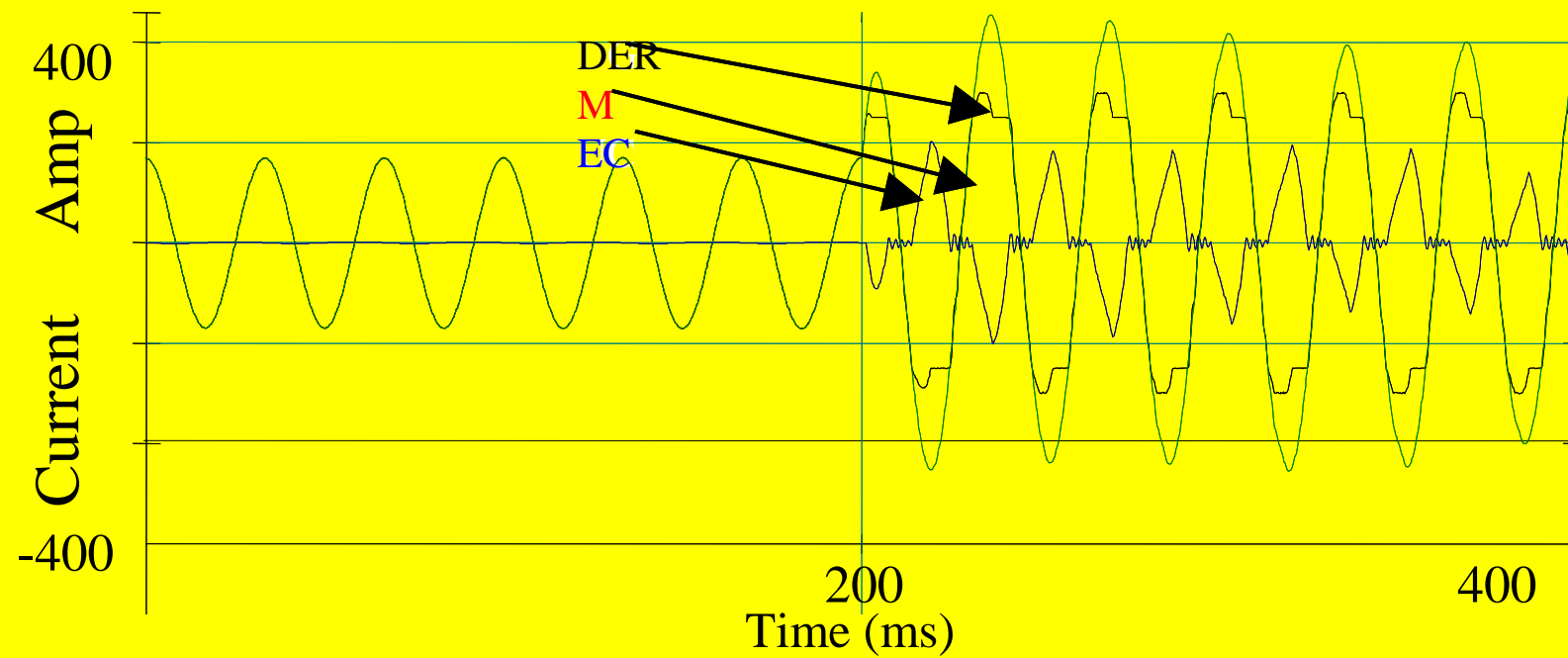
Possible Solutions to Motor Start Problem

- Proposed-- DER Side

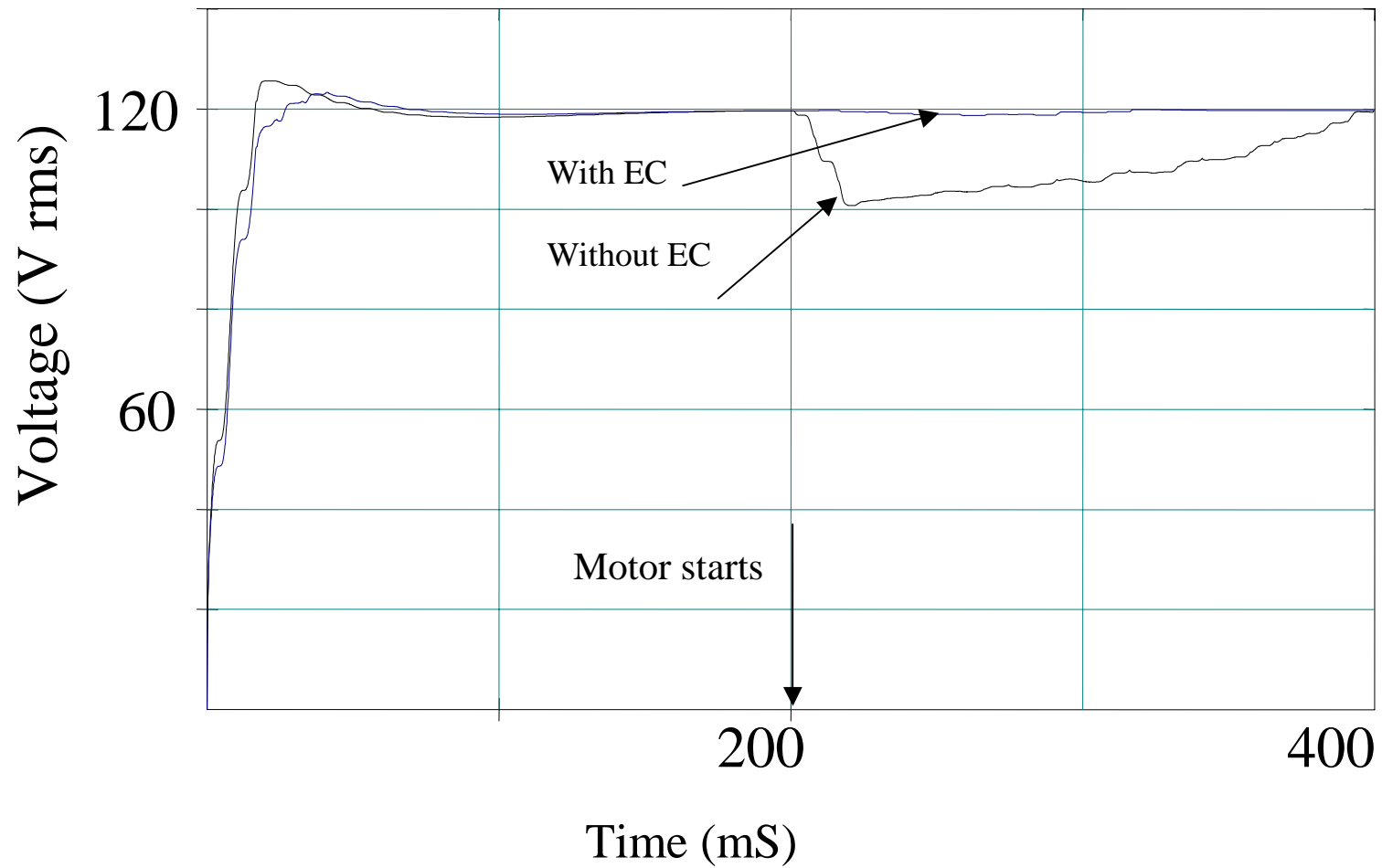


EC provides supplementary current to sustain DER

Proposed Approach



Proposed Approach



Design Considerations

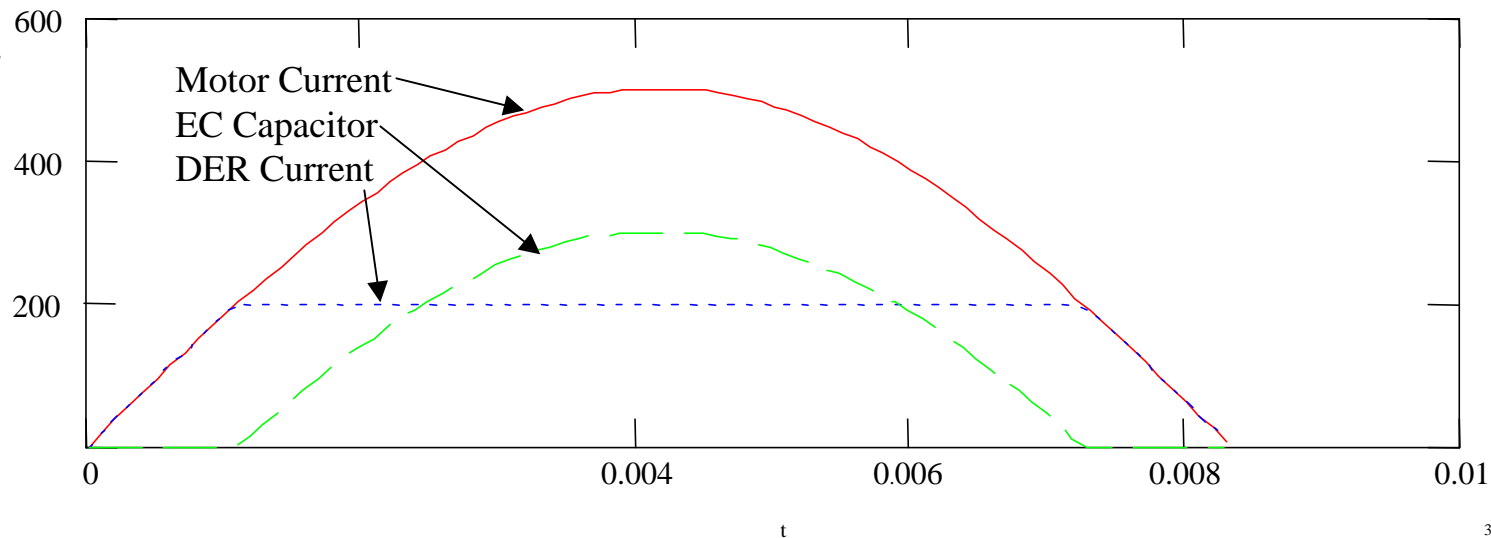
- PCS Design
- EC Capacitor sizing

PCS Considerations

EXPECTED TO BE VERY SIMPLE
ECONOMICAL

- Simple 'square wave' type
- Voltage Source
- No special filtering
- Sized for 1 sec, peak current requirement
- Controlled by DER

PCS Considerations



There is no prescribed waveform for EC Capacitor current

It merely provides the excess current needed

Can use relatively low frequency switching



EC Capacitor

Technical characteristics of
"pulse" type capacitor module
10EC104.2-20-13/6.5-0.006

Rated operating voltage window, V	13 - 6.5
Maximum operating voltage, V	14.5
Capacitance, F, not less than	320
Internal resistance at +20 °C (-30 °C), mOhm, not more than	6 (9)
Energy stored in rated operating voltage window, kJ, not less than	20
Maximum power at +20 °C, kW	7
Charge time, minutes	0.5 - 3.0
Cycling capacity (number of charge/discharge cycles), not less than	100000
Operating temperature range, °C	-50 / +50
Weight, kg, not more than	5
Overall dimensions (L×W×H), mm, not more than	265×63×163

300 V , ~25 F

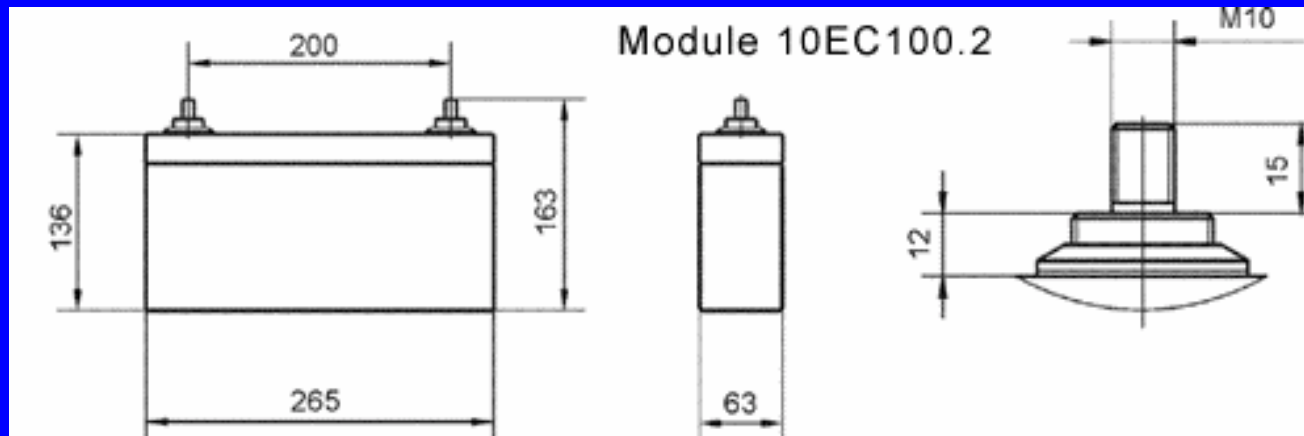
2500 A-S

2 Strings

24 Cap/String

Resistance ~0.1 ohm

.2 m3 , 240 kg



Advantages of EC Capacitors

High Specific Energy- Small Footprint

High Specific Power

Low Maintenance

Wide temperature range

Disadvantages of EC Capacitors

High resistance— Have to charge to a higher voltage

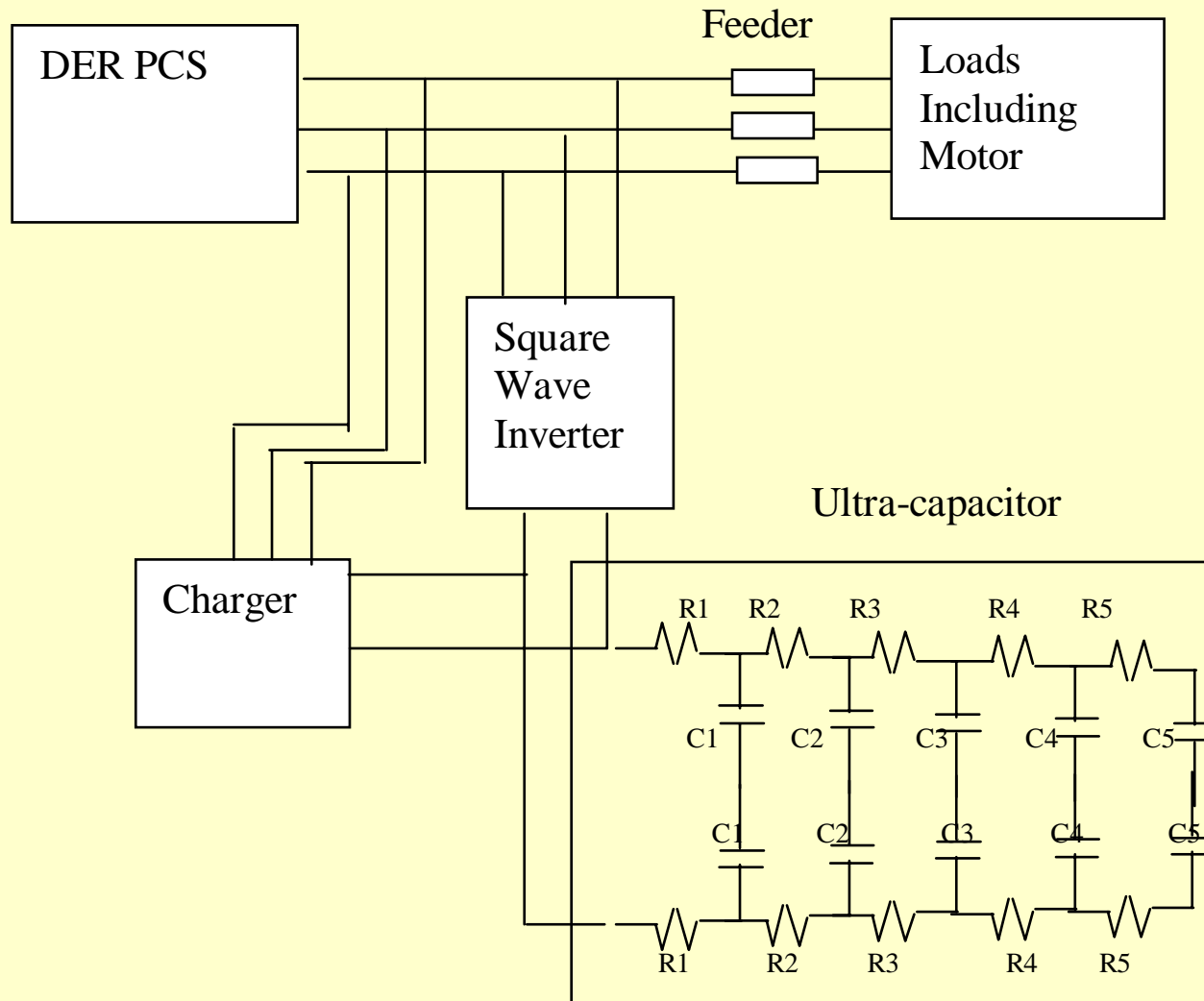
Lossy

Higher voltage implies difficulty charging

EC Capacitor Sizing

- Developed a system model
- Assumed ideal micro-turbine
 - modeled PCS only
- Alternative Transients Program (ATP)
- Capacitor Model from Dr. John Miller
- Looked at starting a very Large motor—
40 HP

EC Capacitor Sizing



EC Capacitor Sizing

Capacitor stored energy must support

Part of Kinetic Energy needed to start
Some Oscillating Energy Flow

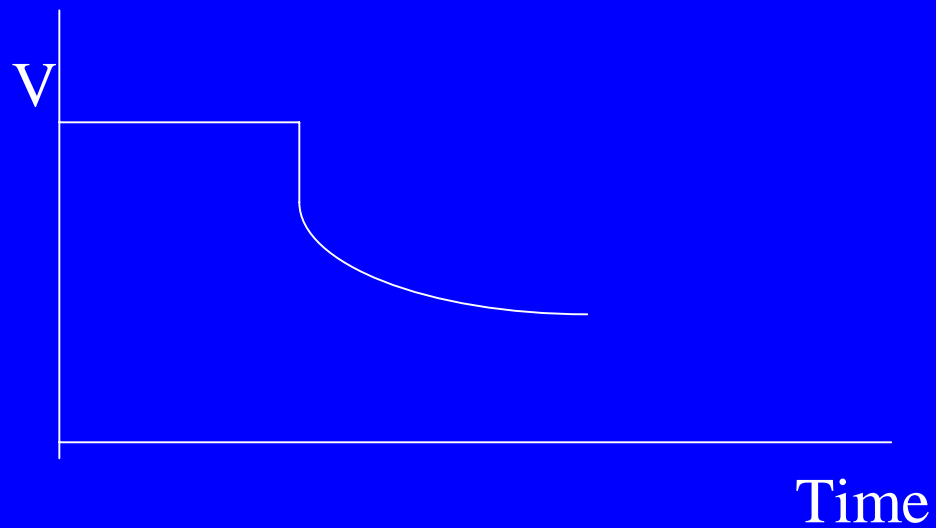
Series resistance is a Primary Limitation.

Causes significant voltage drop when EC Capacitor
supplies surge current

Larger capacitor is needed to keep resistance small

Capacitor Voltage Behavior

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RESULTS

- 75 kW 120/208 V DER
- Assume starting 10-40 HP motor
- EC Capacitor
0.5-5 F, 400-600V dc

RESULTS

- PCS
 - Voltage Source Inverter for dc 600V-ac
120/208; 1200V, 800 A IGBT
 - Charging through bridge diodes , boost circuit
- The 40 HP motor drives the design towards higher rated semi-conductor devices (1200 V IGBTs)
- Can be further optimized

STATUS

- Provided Recommendations/Specification for EC Capacitors
- Economics
- Capacitors have been ordered PCS Specified/ Design Discussed

Next Step

- Plan to implement prototype
- Controller design needed
- Better understanding of capacitor behavior
- Test
- Revise simulation and derive optimized design
- Multiple DERs?

CONCLUSIONS

- Proposed a device that augments DER capability
- DER based solution
- Will allow DER to supply transient loads
- Makes DER more attractive
- Allow viable DER islands